
PHILIPS
LED Modules
Design-in Guide
Fortimo SLM
LED
boxsprings
Excellent color quality and flexibility
Fortimo LED SLM Gen 4 Design-in Guide

Contents

General introduction

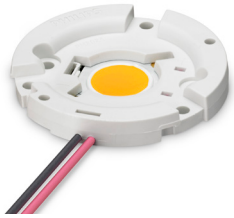

Figure 1. Fortimo LED SLM Gen 4 Module

Thank you for choosing the Philips Fortimo LED SLM Gen 4. In this guide you will find the information required to design this module into a luminaire.

Information and support

If you require any further information or support, please consult your local Philips sales representative or visit our website: www.philips.com/ledmodulesna.

Warnings and instructions

When using a driver, intended for these modules:

Warnings

- The Philips Fortimo LED SLM Gen 4 Modules must be operated with UL Class 2 drivers!
- Avoid touching the light emitting surface!

Safety warnings and installation instructions

To be taken into account during design-in and manufacturing.

Design-in phase

- Do not apply mains power to the module (Fortimo LED SLM Gen 4 CoB and holder) directly.
- Connect the modules and drivers before switching on mains.
- Provide adequate environmental protection.
- Due to the increased Tcase nominal temperature of the module to 85˚C, it is important to take into account the maximum touchable metal surface temperatures of the luminaire. With such a high Tc temperature the maximum temperature for touch safety can easily be exceeded.
- Avoid contamination (direct or indirect) from any incompatible chemicals reacting with the silicone. A list of incompatible chemicals is provided in the chapter for Compliance and Approval.

Manufacturing phase

- Do not use products in case the phosphor on the CoB is discolored/scratched or if the holder is broken.
- Do not drop the Fortimo LED SLM or damage in any way.
- Connect the modules and drivers before switching on mains.
- Avoid contamination (direct or indirect) from any incompatible chemicals reacting with the silicone. A list of incompatible chemicals is provided in the chapter for Compliance and Approval.

Installation and service for luminaires incorporating the Fortimo LED SLM system

- Do not service the luminaire when the mains voltage is connected; this includes connecting or disconnecting the Fortimo LED SLM holder from the driver.

Philips design-in support is available; please contact your Philips sales representative.

Introducing the Philips Fortimo SLM Gen 4 system

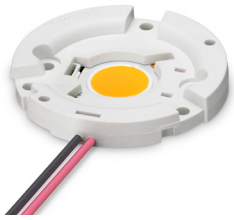

Figure 2. Zhaga certified Fortimo LED SLM Gen 4 Module

* See page 7 for information on Zhaga.

Application information

The Philips Fortimo LED Spotlight Module (SLM) is a high-performance, compact and cost-effective series of products for general and accent lighting. The Fortimo SLM offers a long-lifetime and energy-efficient lighting solution for retail, hospitality and general downlighting applications. It is consistent with other Fortimo families of modules, delivering a high quality of light and peace of mind.

Module types

The Fortimo LED SLM Gen 4 Module comprises of a range of CoBs and holders with fitted pre-tinned cables. The user can choose different resistor values (to be used in the driver) in order to operate any of these modules at different currents to obtain a required lumen output. Fortimo SLM Gen 4 Module provides the user with the flexibility to use the CoB at various operating points in order to achieve a high lm/W or a high lumen per dollar. This provides the user with a full portfolio encompassing a wide range of products.

Warnings

On ordering a Fortimo SLM Module, the customer will receive a box stating the lumen output and color of the requested CoB. Please note that once opened, it is difficult for the user to differentiate between CoBs of different colors. Care must be taken to ensure that such a situation does not occur.

In this guide you will find the specific information required to develop a luminaire based on the Philips Fortimo LED SLM Module. Product specific data can be found in the associated datasheet on www.philips.com/ledmodulesna.

Choosing the correct Fortimo LED SLM Module

The Fortimo SLM Module is offered in a wide range of options. Please refer to the appropriate datasheets for details about each module. It is possible to choose any of the modules based on the standard settings, along with the appropriate driver and recommended Rset. This module can then be used at a number of different operating points to suit your needs.

For example, the Fortimo LED SLM 2000lm 830 L13 G4 Module would have a standard operating point which would give the lumen output as specified at 2000lm providing you with a high lm/W. To run the module at this point, a list of appropriate drivers and Resistor (Rset) is listed in the module datasheet, which can be found at www.philips.com/ledmodulesna. As an alternative, flexibility is offered to choose another Rset with this module to change the operating point in order to get a higher lumen per dollar.

Naming of the Fortimo LED Spotlight Modules

The names of the modules are defined as shown in the example below:

Fortimo LED SLM 3000lm 830 L15 G4

Fortimo	Our brand name for high-quality, efficient, smart, future-proof and reliable LED lighting
LED	The source used
SLM	Spotlight Module
3000lm	3000 lumen, typical light output (changes depending on mode)
830	For a color rendering index >80; 30 stands for a CCT of 3000 K
L15	LES (Light Emitting Surface) has a diameter of 15 mm
G4	Indicates the fourth generation

Assembling your Fortimo LED Spotlight Module

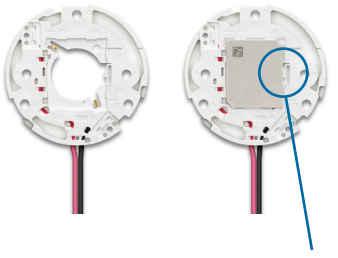

Figure 3. SLM holder and assembly

The Fortimo SLM Module is delivered to you as a combination of the CoB and holder. To assemble the two, please ensure that the + and – sign on the CoB are aligned with that on the holder. The CoB must be clicked into the slot by pushing back onto the spring.

Can the module be used in outdoor luminaires?

Neither the Fortimo LED Module nor the LED driver has an IP classification. If these products are used in luminaires for outdoor applications, it is up to the OEM to ensure proper protection of the luminaire. Please consult us if you wish to deviate from the design rules described in this guide.

In this guide

Figure 4. Fortimo SLM COB

The tinned cables come in a length of 60cm. The OEM can cut this to the length required.

Please note: It is advised to avoid sharp corners in your luminaire where the wires need to pass. This is done to avoid breakage of wires.

On top of this broad range in standard settings and building blocks, the Fortimo LED SLM portfolio provides the luminaire manufacturer with a high level of flexibility to obtain a specific luminaire performance, while using the same components. In combination with our Xitanium LED drivers, the user has the possibility to drive the module at different currents in order to achieve a high lm/W or a high lumens per dollar at different lumen outputs.

Philips Advance Xitanium LED Drivers for Fortimo LED SLM Gen 4

These highly efficient LED drivers are designed for the Fortimo LED Modules. These are available as a dimmable (0-10V dimming/phase dimming) option and with adjustable output current by dip switches or Rset resistor.

More information about the Xitanium drivers for Fortimo LED SLM Gen 4 modules can be found in the datasheets. These documents can be downloaded via www.philips.com/leddrivers.

Figure 5. Philips Bodine BSL17C-C2 Emergency LED Driver

Measurements showing compliancy to Zhaga book 3 Version 1.2 have been done on the 3000lm L15 module.

Philips Fortimo LED SLM Gen 4 Module is a Zhaga certified light engine. Visit www.zhagastandard.org for more information.

Emergency Application

All commercial and government buildings in the U.S. require emergency lighting in order to meet the Life Safety Code NFPA 101. Philips Emergency Lighting offers the BSL17C-C2 emergency LED driver specifically designed for the Fortimo SLM Gen 4. When AC power is lost, the BSL17C-C2 takes over operation of the LED module for 90 minutes to help comply with emergency code requirements. The BSL17C-C2 is Class 2, UL Component Recognized and CSA Certified. Please check the emergency driver datasheet for the latest wiring diagram.

For more information, please visit the Philips Emergency Lighting website at www.bodine.com/products/specs/bsl17cc2.html. Emergency product training videos can be found online (www.youtube.com/user/PhilipsBodine). To go directly to this spec sheet, use http://www.bodine.com/downloads/specs/BSL17C-C2.spec.(std).L2300223.pdf.

Zhaga

Zhaga is a global consortium from across the lighting industry. The overriding aim is to bring standardization to applications in general lighting by creating well defined interface specifications. This ensures the interchangeability of LED light sources from different manufacturers. The Fortimo LED SLM Gen 4 Modules are Zhaga compatible.

For more information on Zhaga, please refer to the website: http://www.zhagastandard.org/

Optical design-in

Light distribution

Fortimo LED SLM Gen 4 generates a Lambertian beam shape (see Figure 6). The secondary optics design should not cover the exit aperture. The IES (or .ldt) files are available via the website www.philips.com/ledmodulesna.

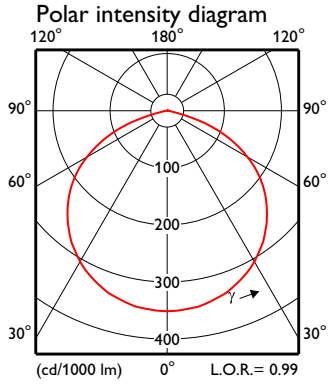

Figure 6. Light distribution diagram

Reflector design limits

The graphs below (Figure 7 and Figure 8) give an indication of the relation between the diameter of the reflector exit aperture and the minimum beam angle (FWHM) or beam peak intensity that can be achieved with Fortimo LED SLM Gen 4 Modules.

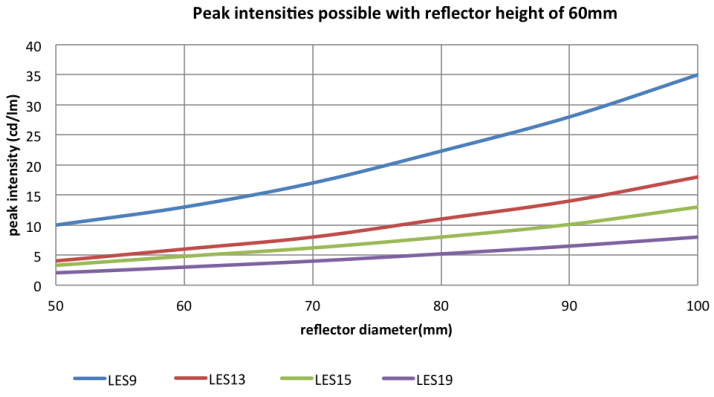

Figure 7. Peak intensities

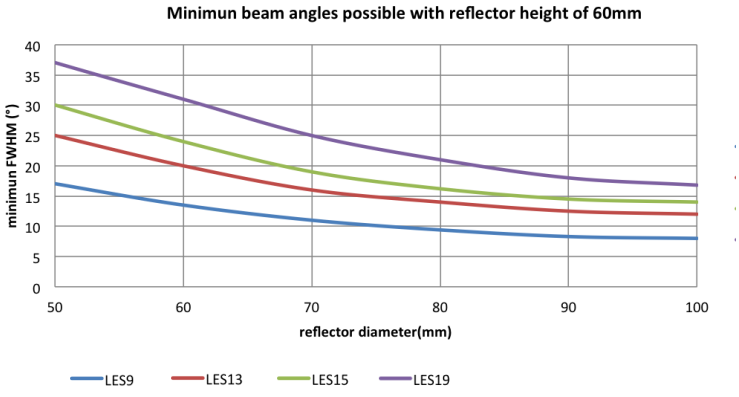

Figure 8. Minimum beam angles

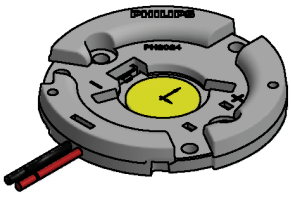

Figure 9. Fortimo SLM Gen 4 LES13

Ray sets

The following ray set files are available for customer use and can be downloaded from www.philips.com/ledmodulesna. All ray set files are available containing 100.000, 500.000 and 5.000.000 rays.

Software	File extension
ASAP	.dis
Light Tools (ASCII)	.ray (zipped)
TracePro/Oslo (ASCII)	.dat (zipped)
Zemax	.dat

Table 1. Ray set files

The origin of the ray sets is shown in the pictures on the left, and it coincides with the origin of the CAD file:

- X = 0 and Y = 0 at the center of the module.
- Z = 0 at the emitting surface (2mm below the inner flat surface of the cover).

Color consistency

Color consistency refers to the spread in color points between modules. It is specified in SDCM (Standard Deviation of Color Matching) or MacAdam ellipses, which are identical. The current general specification of all the Fortimo LED SLM Gen 4 Modules is 3 SDCM.

Color targets

The color target points of the Fortimo LED Spotlight Modules are found in the respective datasheets on www.philips.com/ledmodulesna.

Spectral light distribution

The typical spectral light distributions of the Fortimo LED SLM Gen 4 colors are shown in the respective datasheets on www.philips.com/ledmodulesna.

Complementary reflector partners

Secondary optics is not part of the Fortimo LED SLM system offering. However, there are many reflector companies that have a standard portfolio of compatible reflectors available, enabling fast time to market. Table 2 gives a list of complementary partners offering compatible reflectors for Fortimo LED Spotlight Modules.

The following are examples of reflector products that can be used with the Fortimo LED SLM system. Reference to these products does not necessarily mean they are endorsed by Philips. Philips gives no warranties regarding these products and assumes no legal liability or responsibility for any loss or damage resulting from the use of the information given here.

Complementary reflector partners
Alux Luxar (www.alux-luxar.de)
Jordan (www.jordan-reflektoren.de)
NATA (www.nata.cn)
Widegerm (www.widegerm.com.hk)
LEDIL (www.ledil.com)
Almeco (www.almecogroup.com)

Table 2. Complementary reflector partners

Starting characteristics

The Fortimo Modules light up milliseconds after being switched on, which is a general characteristic of LEDs.

Mechanical design-in

Fortimo LED SLM Gen 4 dimensions

The Fortimo LED SLM Gen 4 Modules comply with the Zhaga* book 3 for LED accent lighting modules. 3D CAD files can be downloaded from our website www.philips.com/ledmodulesna. Basic dimensions for each module can also be found in the datasheets, which are also available at mentioned website.

Recommended torque

M3 screws are used for mechanical fixation of Fortimo LED SLM Module to the heat sink. The recommended torque for mechanical fixation is 0.6 Nm (assuming pre-taped holes are present in the heat sink).

*Measurements showing compliancy to Zhaga book 3 Version 1.2 have been done on the 3000lm L15 module.

Thermal design-in

The critical thermal management points for the LED module are set out in this chapter in order to facilitate the design-in of Fortimo LED Spotlight Modules (SLM). If these thermal points are taken into account, this will help to ensure optimum performance and lifetime of the LED system.

Optimum performance

To ensure optimum performance, the Fortimo LED SLM system must operate within specified temperature limits.

Test requirements

Measurements, e.g., of temperature, luminous flux and power, are reliable once the luminaire is thermally stabilized, which may take between 0.5 and 2 hours and is defined as at least three readings of light output and electrical power over a period of 30 minutes taken 15 minutes apart with stability less than 0.5%.

Please note: Thermal stability can be considered if the temperature changes are less than 1°C over three measurements taken 15 minutes apart.

Measurements must be performed using thermocouples that are firmly glued to the surface (and not, for example, secured with adhesive tape).

Critical measurement points

Because LEDs are temperature sensitive, LED modules require a different approach with respect to the maximum permissible component temperature. This is different from most other types of conventional light sources.

For LEDs the junction temperature is the critical factor for operation. Since there is a direct relation between the case temperature and the LED junction temperature, it is sufficient to measure the aluminum casing of the LED module at its critical point. The critical point is on the rear surface of the LED module, as shown in the Figure 10. If the case temperature (Tc) at the critical measurement point exceeds the recommended maximum temperature, the performance of the LEDs will be adversely affected, for example in terms of light output or critical failures.

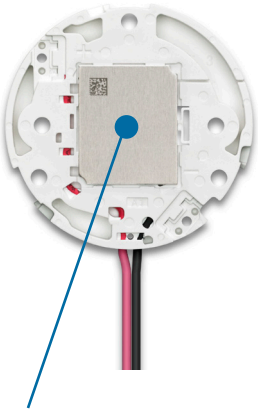

Figure 10. Tc measurement point

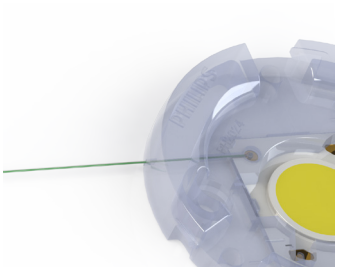

Figure 11A.

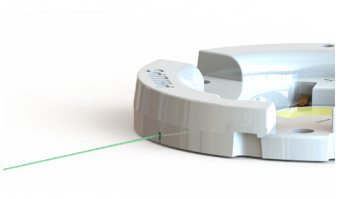

Figure 11B.

Figure 11A and B. Thermocouple wire fed through provision in holder

To aid easy design-in of the Fortimo LED SLM Gen 4, a Tp point is introduced at the top side of the LED module. The Tcase point at the back still remains leading. However, under certain circumstances, the temperature measurements on the Tp point can be used to predict the temperature of the Tcase point at the back of the module. For this purpose, there is a provision in the SLM holder to feed through a thin thermal couple wire shown in Figures 11A and 11B. The correlation between the Tp point and the Tcase point is influenced by the quality and performance of the thermal interface with the heat sink and the type and geometry of the heat sink. The correlation between Tsense and Tcase has been calculated based on a laboratory test with thermal paste and heat sinks with at least 3mm heat sink base thickness. If these conditions are the same, then a difference of 0.3°C/W can be used. Results may vary case by case, and it is best if the measurement reference is made at the customer, using the luminaire in question. It is also important to note that the Tcase temperature is always leading. If support is needed, please ask your Philips sales representative about our design-in service.

Tc-nominal and Tc-max

With the introduction of Fortimo LED SLM Gen 4, the luminaire manufacturers are enabled to make luminaires even more compact due to a smaller heat sink. For this, Tc-max has been introduced. The Tc-max value for the Fortimo LED SLM Gen 4 is set to 95°C, and it is the maximum temperature at which the Philips Fortimo LED SLM Gen 4 Modules can be operated. Details about specific module types, drive currents and temperatures can be found in the specific datasheets at www.philips.com/ledmodulesna.

At Tc-nominal of 85°C all the specifications mentioned in the Fortimo LED SLM Gen 4 datasheets and design-in guide are valid and a 5-year limited system warranty (http://www.usa.lighting.philips.com/connect/tools_literature/warranties.wpd) is applicable in combination with a Philips Advance Xitanium LED Driver.

Please note: With no Rset connected to the driver, the driver goes to its default current (specified in the driver datasheet). This default current might exceed the maximum current specified for the module.

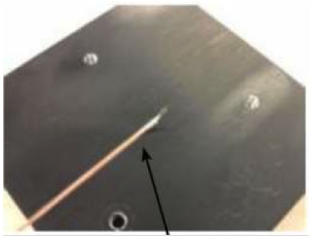

Figure 12. Thin v-groove in the heat sink to embed a thermocouple

How to measure the critical temperature point Tc

The Tc temperature can be measured by making a thin v-groove or a small drill hole in the heat sink to reach the bottom of the LED module. Be sure to measure the temperature of the bottom of the module and not of the thermal interface material (TIM).

Thermal interface material

The function of a thermal interface material is to reduce thermal impedance between the LED module and the heat sink. The thermal interface material replaces air, which is a thermal insulator, by filling the gaps with material that has better thermal conductivity. This is shown diagrammatically in Figure 13 at the bottom of the page.

In general:

- Thermal paste performs better than thermal pads.
- The lower the thermal impedance the better.
- The thickness of the TIM should relate to the surface roughness and flatness of the used heatsink.

Due to the small footprint of the Fortimo SLM Gen 4, it is more sensitive to roughness and surface quality of the heat sink counter surface. It is highly recommended to have this surface clean and free of burs before applying the thermal interface material and the SLM module.

In Table 3 are suggestions for thermal interface material product partners to use with the Fortimo LED SLM Module. Reference to these products does not necessarily mean they are endorsed by Philips. Philips gives no warranties regarding these products and assumes no legal liability or responsibility for any loss or damage resulting from the use of the information given here.

For the Fortimo LED SLM Gen 4 it is recommended to use a thermal paste or phase change material as Thermal Interface Material (TIM). Please also be aware that an electrically insulating phase change material will introduce a thermal penalty compared to non-electrically isolating phase change material. Thick thermal interface materials are not recommended.

Thermal interface partners
Laird Technologies (www.lairdtech.com)
The Bergquist Company (www.bergquistcompany.com)

Table 3. Thermal interface partners

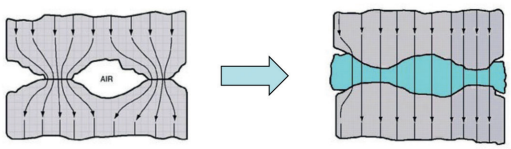

Figure 13. The working principle of thermal interface material (TIM)

Electrical and thermal analogy

Standard static thermal situations can be modeled using "thermal resistances." These resistances behave like electrical resistances. The analogy between electrical and thermal resistances is explained in Figure 14. The electrical units are shown on the left, while the thermal equivalents are given on the right in the diagram. With a known voltage difference at a certain current it is possible to calculate the electrical resistance using Ohm's law. The same applies for a thermal resistance. If the temperature difference and the thermal power are known, the thermal resistance can be calculated using the thermal Ohm's law. Please note that using the concept of thermal resistances is a strong simplification of the actual physics of heat transfer to aid in understanding of heat flow and temperature.

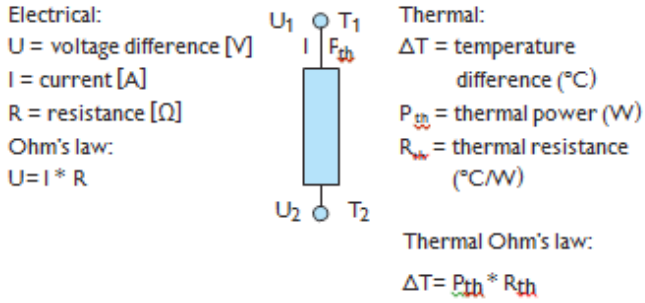

Figure 14. Electrical and thermal analogy

Thermal model

A thermal model that can be used to determine the required thermal performance of the cooling solution for the LED module is shown in Figure 15.

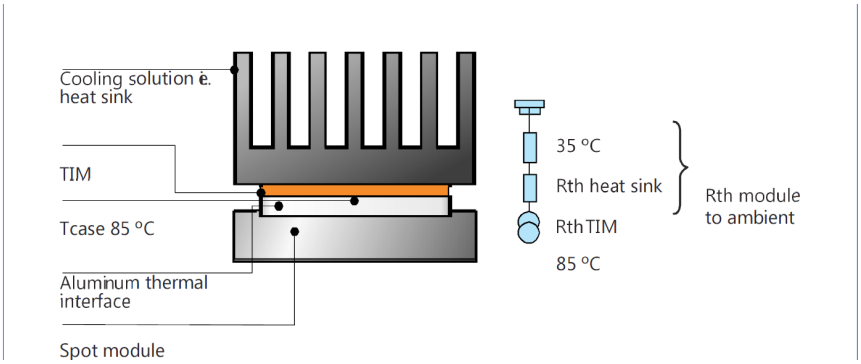

Figure 15. Thermal model

A simplified model of the thermal path from LED module to ambient; Tc of 85˚C is used as an example.

Thermal design of a heat sink

A successful thermal design-in means that the Tc temperatures of the LED module is within thermal specifications at given maximum operating ambient of the luminaire and the maximum temperature difference between Tc and Tambient should not exceed 60˚C for Fortimo LED SLM Gen 4.

Remarks:

- For track spot lighting applications, a minimum of 25˚C design ambient is recommended.
- For recessed spot lighting applications, a minimum of 35˚C design ambient is recommended.

If the expected maximum operating ambient for the luminaire is <25˚C ambient, the luminaire still needs to be tested within thermal specifications of Tcase nominal in a lab environment at 25˚C ambient.

Warnings

The maximum temperature difference between Tc and Tambient should not exceed 60˚C for SLM Gen 4, otherwise it could lead to a reduction in the lifetime of the system.

Warnings

Due to the increased Tcase nominal temperature of the Fortimo LED SLM Gen 4 to 85˚C, it is important to take into account the maximum touchable metal surface temperatures of the luminaire during design. With such a high Tcase temperature the maximum temperature for touch safety can easily be exceeded.

Thermal data for Fortimo SLM Modules

Name	Flux Typ. [lm]	Drive Current [mA]	Voltage [V]	Typical Thermal Power [W]	Max Pthermal @ worse case [W]
Fortimo LED SLM 1100lm 827 L9 G4 NA	1100	300	35.4	7.7	8.1
Fortimo LED SLM 1100lm 830 L9 G4 NA	1200	300	35.4	7.4	7.9
Fortimo LED SLM 1100lm 835 L9 G4 NA	1250	300	35.4	7.3	7.8
Fortimo LED SLM 1100lm 840 L9 G4 NA	1270	300	35.4	7.3	7.7
Fortimo LED SLM 1100lm 927 L9 G4 NA	930	300	35.4	7.8	8.3
Fortimo LED SLM 1100lm 827 L9 G4 NA	1700	500	38.1	14.7	15.7
Fortimo LED SLM 1100lm 830 L9 G4 NA	1850	500	38.1	14.4	15.4
Fortimo LED SLM 1100lm 835 L9 G4 NA	1920	500	38.1	14.2	15.2
Fortimo LED SLM 1100lm 840 L9 G4 NA	1960	500	38.1	14.1	15.1
Fortimo LED SLM 1100lm 927 L9 G4 NA	1430	500	38.1	14.9	15.9
Fortimo LED SLM 1100lm 827 L13 G4	1160	300	33.9	7	7.4
Fortimo LED SLM 1100lm 830 L13 G4	1240	300	33.9	6.8	7.2
Fortimo LED SLM 1100lm 835 L13 G4	1290	300	33.9	6.7	7.1
Fortimo LED SLM 1100lm 840 L13 G4	1330	300	33.9	6.6	7.0
Fortimo LED SLM 1100lm 927 L13 G4	970	300	33.9	7.6	8.1
Fortimo LED SLM 1100lm 827 L13 G4	1810	500	35.9	13.1	13.9
Fortimo LED SLM 1100lm 830 L13 G4	1950	500	35.9	12.8	13.7
Fortimo LED SLM 1100lm 835 L13 G4	2030	500	35.9	12.6	13.5
Fortimo LED SLM 1100lm 840 L13 G4	2080	500	35.9	12.5	13.3
Fortimo LED SLM 1100lm 927 L13 G4	1520	500	35.8	14.2	15.1
Fortimo LED SLM 2000lm 827 L13 G4	1850	500	34.6	12.2	13.0
Fortimo LED SLM 2000lm 830 L13 G4	2020	500	34.6	11.9	12.6
Fortimo LED SLM 2000lm 835 L13 G4	2100	500	34.6	11.7	12.4
Fortimo LED SLM 2000lm 840 L13 G4	2150	500	34.6	11.6	12.3
Fortimo LED SLM 2000lm 927 L13 G4	1570	500	34.6	12.5	13.2
Fortimo LED SLM 2000lm 827 L13 G4	2590	750	36.3	20.5	21.8
Fortimo LED SLM 2000lm 830 L13 G4	2820	750	36.3	20	21.3
Fortimo LED SLM 2000lm 835 L13 G4	2940	750	36.3	19.7	21.0
Fortimo LED SLM 2000lm 840 L13 G4	3000	750	36.3	19.5	20.8
Fortimo LED SLM 2000lm 927 L13 G4	2180	750	36.3	20.8	22.2
Fortimo LED SLM 3000lm 827 L15 G4	2760	750	34.7	18.3	19.4
Fortimo LED SLM 3000lm 830 L15 G4	2970	750	34.7	17.9	19.0
Fortimo LED SLM 3000lm 835 L15 G4	3090	750	34.7	17.6	18.7
Fortimo LED SLM 3000lm 840 L15 G4	3170	750	34.7	17.3	18.4
Fortimo LED SLM 3000lm 827 L15 G4	4110	1200	36.7	33.2	35.3
Fortimo LED SLM 3000lm 830 L15 G4	4420	1200	36.7	32.6	34.7
Fortimo LED SLM 3000lm 835 L15 G4	4600	1200	36.7	32.1	34.2
Fortimo LED SLM 3000lm 840 L15 G4	4720	1200	36.7	31.7	33.8
Fortimo LED SLM 4500lm 830 L19 G4	4860	1200	35.3	29.4	31.4
Fortimo LED SLM 4500lm 835 L19 G4	5060	1200	35.3	29	30.9
Fortimo LED SLM 4500lm 840 L19 G4	5160	1200	35.3	28.7	30.6
Fortimo LED SLM 1100lm 930 CW L9 G4 NA	930	300	35.4	7.9	16.1
Fortimo LED SLM 1100lm 930 CW L13 G4	1490	500	35.8	13.7	14.6
Fortimo LED SLM 2000lm 930 CW L13 G4	2180	750	36.3	21.1	22.5
Fortimo LED SLM 3000lm 930 CW L15 G4	2770	950	35.6	25.7	27.4
Fortimo LED SLM 3800lm 930 CW L19 G4	3610	1200	35.2	31.9	34.0

Table 4. Thermal data for Fortimo SLM Modules

Active and passive cooling

In theory two thermal solutions are possible.

Active cooling

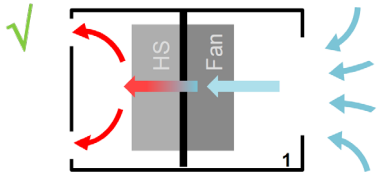

Figure 16. Design guidelines for active cooling solutions

With this method the air is forced to flow by means of a fan or membrane, which enhances the thermal dissipating capacity of the heat sink. As a result, a smaller heat sink can be used and the orientation of the heat sink has less impact on the thermal performance. A potential side effect is that the fan or membrane might produce noise and consume extra energy.

Furthermore, the specified lifetime of the fan should match that of the application.

Design guidelines for active cooling

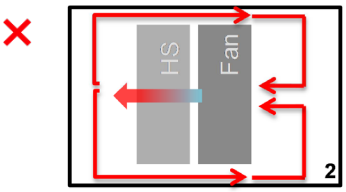

Figure 17. Design guidelines for active cooling solutions

Design guidelines for active cooling include:

- The luminaire should be equipped with an inlet for cool air and an outlet for hot air (Figure 16).
- The airflow from the inlet to the outlet should be smooth and without restriction in order to limit vibration, recirculation and noise.
- Recirculation of hot air (Figure 17) inside the luminaire should be prevented, as this will lead to a lower thermal performance and higher noise level.
- Unnecessary openings near the fan in the luminaire housing (Figure 18) should be avoided in order to help contain any noise from the fan.

Passive cooling

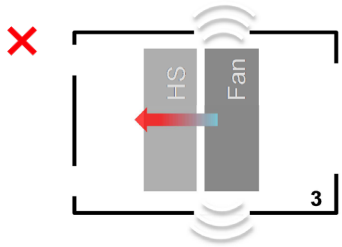

Figure 18. Design guidelines for active cooling solutions

Passive cooling systems are based on the fact that hot air moves upward, thus creating airflow along the surfaces. This is called natural convection. There are many standard heat sinks available, but it is also possible to design your own heat sink.

In general, a passive cooling solution requires a larger heat sink than an active cooling solution.

Design guidelines for passive cooling

Before starting to perform any calculations, an important point to consider is the airflow. In general hot air moves upward at a relatively low speed. The shape and position of the heat sink will affect the airflow. Ideally, the fins should be parallel to the direction of airflow. Closure of the top of the profile will reduce the cooling capacity of the heat sink and should therefore be avoided during design and installation.

Some additional design guidelines for passive cooling include:

- Limit the number of thermal interfaces in the thermal path from module to ambient.
- Thick fins conduct heat better than thin fins.
- Large spacing between fins is better than small spacing between fins.
- Make cooling surfaces more effective by using proper conductive materials, appropriate thickness and correct fin orientation.
- Thermal radiation plays a significant role => anodized or powder-coated surfaces are preferable to blank surfaces.

Complementary thermal solution partners

Thermal solutions do not form part of the Fortimo LED SLM system offering. This is an added-value area for OEMs, offering the possibility to differentiate. However, there are many thermal solution companies that have a standard portfolio of compatible heat sinks available, enabling quick and easy luminaire creation. Table 5 provides a list of complementary partners offering compatible cooling systems for Fortimo LED SLM Modules.

Reference to these products does not necessarily mean they are endorsed by Philips. Philips makes no warranties regarding these products and assumes no legal liability or responsibility for any loss or damage resulting from the use of the information given here.

Complementary heat sink partners
Sunon (www.sunon.com)
AVC (www.avc.com.tw)
Nuventix (www.nuventix.com)
Wisefull (www.wisefull.com)
MechaTronix (www.mechatronix-asia.com)

Table 5. Complementary heat sink partners

Electrical design-in and flexibility

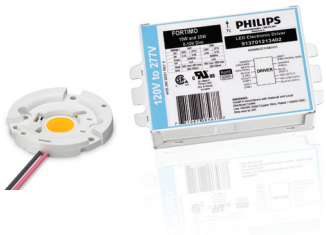

Figure 19. 25W Smart Mate driver and 20W track driver

Connection to the mains supply

The mains supply must be connected to the LED driver.

UL Class 2 drivers

The Fortimo LED SLM Gen 4 products are designed to be used with UL Class 2 drivers.

Tune the luminaire's flux (lm) and efficacy (lm/W)

The Fortimo LED SLM specifications are provided under nominal conditions, like nominal flux at nominal current. It is, however, possible to deviate from this nominal current. By altering the current, we can obtain different flux outputs. At the same time, the required forward voltage (Vf) also changes, leading to a change in the efficacy (lm/W) as shown in Figure 20. The following sections explain the impact and boundaries.

Effect of choosing a different current value

In case the customer chooses to set the current (either by applying an Rset resistor or by dip switches) other than nominal, the lifetime and reliability of the Fortimo LED SLM must be taken into account. The following current regions can be distinguished:

1. Current < nominal current[1] (mA)
   a. Efficacy (lm/W) higher than nominal value lumen output (lm) lower than nominal value
   b. Lifetime > 50,000 hours[2]
2. Current between nominal current and absolute maximum current[3] (mA). Your warranty may be affected in this case.
   a. Efficacy (lm/W) lower than nominal value lumen output (lm) higher than nominal value
   b. Lifetime may be < 50,000 hours[2]
3. Current > absolute maximum current: do not exceed the absolute maximum current as this can lead your Fortimo LED SLM Module to failure. No warranty applicable in this case.

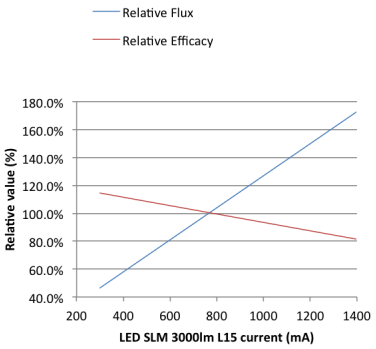

Figure 20. Example graph showing flux and efficacy as a function of current

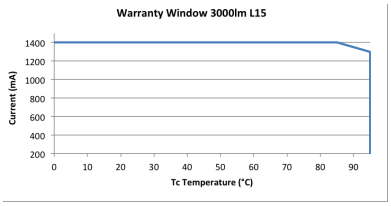

Figure 21. Example warranty window

Please Note: You must check to see if your chosen operating point falls within the warranty window (Figure 21) stated in the datasheets along with the flux tuning graphs as shown in Figure 20. The warranty is applicable for the Philips Fortimo LED SLM Modules for one switching cycle per day in combination with a UL Class 2 driver.

1 Nominal current at which performance and lifetime is specified
2 The rated average life is based on engineering data testing and probability analysis. The hours are at the L70B50 point.
3 Maximum current tested for safety

Set the output current via Rset

By making use of a resistor component with a determined Ohm value you can set the required current for your LED module. Use a resistor between Rset2 and SGND terminals. Any through hole or SMD resistor with >0.25W and >20V can be used as RSET between Rset and SGND pins.

Please note that if you have a driver that supports both Rset1 and Rset2, choose Rset2. All future drivers will support Rset2.

Rset component

12 NC	Material Description	Resistance [Ω]
929000727713	Fortimo LED Rset2 NA 300mA	560
929000727813	Fortimo LED Rset2 NA 500mA	1,200
929000727913	Fortimo LED Rset2 NA 750mA	2,050
929000728013	Fortimo LED Rset2 NA 950mA	3,090
929000728113	Fortimo LED Rset2 NA 1200mA	4,780

Table 6. Rset component

Rset2 table

Rset2 [Ω]	Iset [mA]	Rset2 [Ω]	Iset [mA]	Rset2 [Ω]	Iset [mA]	Rset2 [Ω]	Iset [mA]	Rset2 [Ω]	Iset [mA]	Rset2 [Ω]	Iset [mA]
short	min.	255	171	665	335	1740	669	4530	1171	11800	1686
100	100	261	173	681	341	1780	679	4640	1185	12100	1698
102	101	267	175	698	347	1820	689	4750	1198	12400	1708
105	103	274	178	715	354	1870	701	4870	1212	12700	1719
107	104	280	181	732	361	1910	711	4910	1216	13000	1730
110	105	287	184	750	368	1960	724	5110	1239	13300	1739
113	107	294	187	768	374	2000	733	5230	1253	13700	1752
115	108	301	191	787	381	2050	745	5360	1267	14000	1761
118	110	309	194	806	387	2100	757	5490	1281	14300	1771
121	111	316	197	825	394	2160	770	5620	1295	14700	1783
124	113	324	201	845	400	2210	782	5760	1308	15000	1793
127	115	332	204	866	407	2320	806	5900	1322	15400	1802
130	116	340	207	887	414	2360	815	6040	1335	15800	1812
133	118	348	210	909	422	2370	817	6190	1349	16200	1822
137	119	357	214	931	429	2430	829	6340	1362	16500	1829
140	120	365	217	953	436	2490	841	6490	1375	16900	1838
143	122	374	221	976	444	2550	853	6650	1389	17400	1850
147	123	383	225	1000	452	2610	865	6810	1403	17800	1859
150	125	392	229	1020	459	2670	877	6980	1415	18200	1867
154	127	402	233	1050	469	2740	891	7150	1428	18700	1877
158	129	412	237	1070	475	2800	903	7320	1441	19100	1885
162	131	422	241	1100	485	2870	916	7500	1454	19600	1894
165	132	432	246	1130	494	2940	929	7680	1467	20000	1902
169	134	442	250	1150	500	3010	943	7870	1480	20500	1910
174	136	453	254	1180	509	3090	956	8060	1493	21000	1918
178	137	464	259	1210	518	3160	968	8250	1506	21600	1928
182	139	475	263	1240	527	3240	982	8450	1518	22100	1936
187	141	487	268	1270	536	3320	996	8660	1531	23200	1952
191	143	491	270	1300	545	3400	1009	8870	1544	23600	1959
196	145	511	278	1330	554	3480	1022	9090	1557	23700	1960
200	146	523	282	1370	565	3570	1037	9310	1569	24300	1968
205	148	536	287	1400	574	3650	1049	9530	1580	24900	1975
210	151	549	292	1430	582	3740	1062	9760	1592	25500	1982
216	153	562	297	1470	594	3830	1075	10000	1604	26100	1989
221	155	576	302	1500	602	3920	1088	10200	1614	26700	1996
232	161	590	307	1540	614	4020	1103	10500	1629	27000	2000
236	163	604	313	1580	626	4120	1117	10700	1639	open	default
237	164	619	318	1620	638	4220	1131	11000	1653		
243	167	634	323	1650	645	4320	1145	11300	1666		
249	169	649	329	1690	656	4420	1158	11500	1674		

Table 7. Resistance value and corresponding current using Rset2

Rset3 table for XI095C275V054DNF1M driver

Rset [Ω]	Current [mA]	Rset [Ω]	Current [mA]	Rset [Ω]	Current [mA]	Rset [Ω]	Current [mA]
0	1000	470	1131	2400	528	12000	2284
100	1029	510	1142	2700	1575	13000	2321
110	1032	560	1154	3000	1619	15000	2383
120	1035	620	1170	3300	1661	16000	2410
130	1038	680	1185	3600	1700	18000	2458
150	1044	750	1202	3900	1737	20000	2499
160	1047	820	1218	4300	1783	22000	2534
180	1052	910	1239	4700	1826	24000	2564
200	1058	1000	1260	5100	1865	27000	2603
220	1064	1100	1282	5600	1912	30000	2635
240	1069	1200	1304	6200	1962	33000	2663
270	1077	1300	1325	6800	2008	36000	2686
300	1086	1500	1366	7500	2057	39000	2707
330	1094	1600	1386	8200	2102	43000	2730
360	1102	1800	1424	9100	2153	47000	2750
390	1110	2000	1460	10000	2199	>47000	2750
430	1121	2200	1495	11000	2244		

Table 8. Rset3 for XI095C275V054DNF1M driver

Warning

Please note that changing the Rset on the driver changes the current and voltage at which the module operates. You may have to adapt your design accordingly. In case no Rset is used, please check the default setting of your driver. This current may be higher than what your CoB can handle!

Philips Advance Xitanium LED Driver operating window

LED technology is rapidly evolving. Using more efficient LEDs in a next generation means the same light output can be achieved with lower currents. At the same time, LEDs can be driven at different currents levels based on the application requirement. Typically, LED drivers are available in discrete current levels, e. g., 350mA, 530mA or 700mA. It is often necessary to replace a driver when more efficient LEDs become available.

One of the key features of the Philips Advance Xitanium LED Drivers is the adjustable output current (AOC), offering flexibility and future-proof luminaire design. The Xitanium Drivers can operate in a certain “operating window.” This window is defined by the maximum and minimum voltage and current that the driver can handle. An example of an operating window is shown in Figure 22. The area indicates the possible current/voltage combinations. The current you select will depend on the type and manufacturer of the LEDs or the specific LED configuration of the PCB design.

Note: by means of dimming it is possible to go below the minimum value of the specified output current.

The output current of these drivers can be set in two ways.

1. By connecting a specific resistor to the driver's Rset and SGND terminals

2. By dip switches for XI020C050V042RNP1

How to determine what value the output current should be set at will be explained in the next sections.

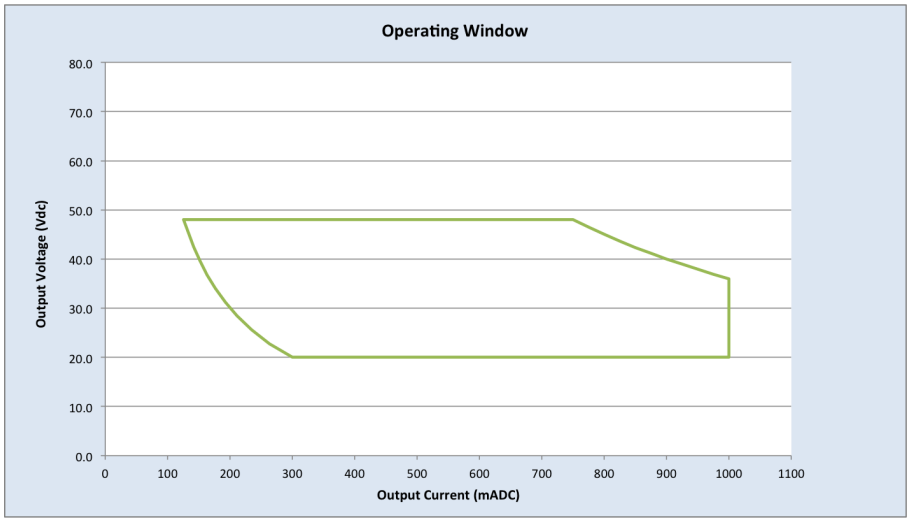

Figure 22. Example operating window for the Xitanium Driver (36W in this case)

1. Required operating point
2. Current can be set to needs within range
3. Driver adapts to required voltage, given it fits range
4. Driver minimum power limit
5. Driver maximum power limit

To select an appropriate driver

Depending on your requirements, several drivers can be a solution for you. The following steps can help you in selecting a driver.

1. Determine your required driver current (Idrive) and voltage (Vf).
2. Calculate the required power (Pdrive) where Pdrive=Vf x Idrive (W).
3. Select the datasheets from the website mentioned above based on the driver having a power greater than the required power.
4. Does the required current fit the current range of the driver? Please check the driver datasheet for max and min driver current.
    - Idriver min ≤ Idrive ≤ Idriver max?
5. Does the required voltage fit the voltage range of the driver? Please check the driver datasheet for its max and min voltage range.
    - Vdriver min ≤ Vf ≤ Vdriver max?
6. Does the required power fit the power range of the driver? In the naming of the driver, you can see the maximum power possible. For example, in the XI036C100V048DNMX, the maximum power is 36W. The minimum power is defined as Idriver min x Vdriver min.
    - Pdriver min ≤ Pdrive ≤ Pdriver max?
7. Choose your preferred dimming.

Driver list

Driver List	Dimming Mechanism	Current Setting Mechanism
XI013C030V048DNM1	0-10V dimming	Rset2
XI020C050V042RNP1	Leading Edge and Trailing Edge	Dip Switch
XI025C100V045DNM1	0-10V dimming	Rset2
XI036C100V048DNMX	0-10V dimming	Rset2
XI050C100V054DNMX	0-10V dimming	Rset2
XI050C100V054XPL1	Trailing Edge and 0-10V dimming@120V only	Rset1, Rset2 or programmable
XI095C275V054DNF5	0-10V dimming	Rset3

Table 9. Driver list

Compatible drivers with Fortimo SLM Gen 4

In the following graph, you can see the various operating windows for the different Philips Advance Xitanium Drivers. Based on the above explained rules, you can now choose the appropriate driver for your Fortimo SLM Module operating point. A list of different drivers that belong to the windows explained is provided in the graphs in Figure 23 and Figure 24. In case of queries, please contact your Philips sales representative.

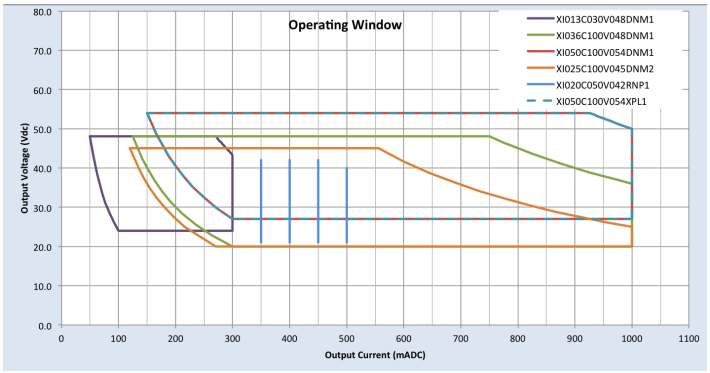

Figure 23. Operating window

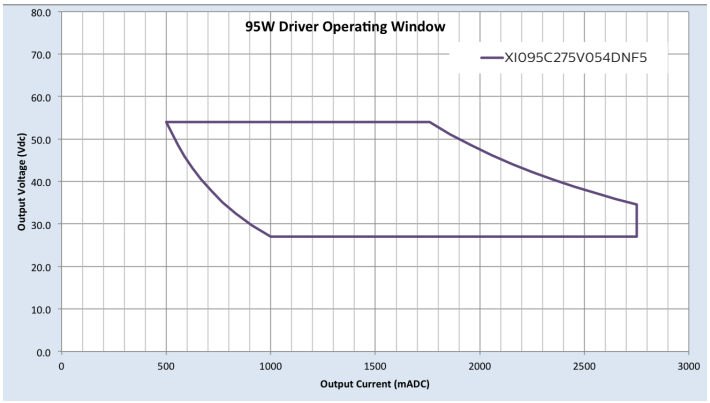

Figure 24. 95W driver operating window

Reliability

Lumen maintenance

L70B50 @ 50,000 hours[2]

The quality of the Fortimo LED SLM portfolio is backed by the Philips claim of B50L70 @ 50,000 hours. This means that at 50,000 hours of operation at least 50% of the LEDs' population will emit at least 70% of its original amount of lumens.

This is contrary to conventional light sources, where some time after Service Life Hours the conventional light source emits no light at all.

In this section the example graphs shown in Figure 25 estimated lumen depreciation curves for different percentage of the population and at nominal Tc temperatures. The actual data for the Fortimo LED SLM Modules can be found in the associated datasheets at www.philips.com/ledmodulesna.

Average rated life is based on engineering data testing and probability analysis. The Fortimo LED SLM Gen 4 Modules are specified to reach L70B50 for the nominal specifications.

Lumen maintenance for B10 and B50

The example graph is showing the lumen maintenance (% of initial lumen over time) for B50 (50% of the population) and B10 (90% of the population).

Please look up the actual lumen maintenance graph in the associated datasheet of the Fortimo LED SLM you are using at www.philips.com/ledmodulesna.

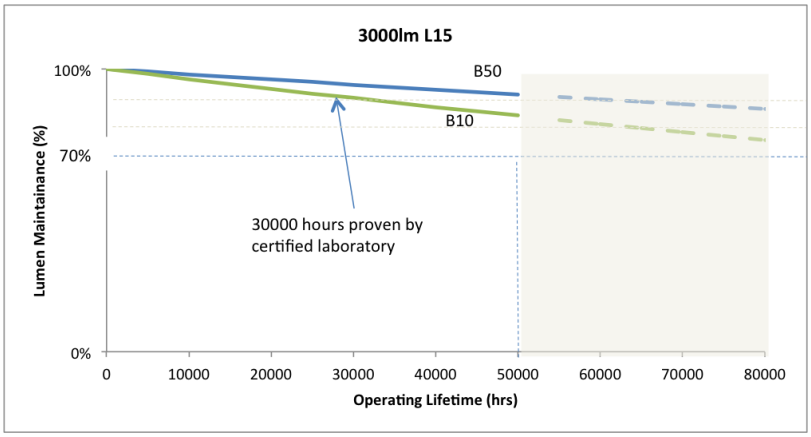

Figure 25. Example lumen maintenance as a function of operating hours for B10 and B50 at Tc nominal

2 The rated average life is based on engineering data testing and probability analysis. The hours are at the L70B50 point.

Complementary partners

Complementary reflector partners
Alux Luxar (www.alux-luxar.de)
Jordan (www.jordan-reflektoren.de)
NATA (www.nata.cn)
Widegerm (www.widegerm.com.hk)
LEDIL (www.ledil.com)
Almeco (www.almecogroup.com)

Thermal interface partners
Laird Technologies (www.lairdtech.com)
The Bergquist Company (www.bergquistcompany.com)

Complementary heat sink partners
Sunon (www.sunon.com)
AVC (www.avc.com.tw)
Nuventix (www.nuventix.com)
Wisefull (www.wisefull.com)
MechaTronix (www.mechatronix-asia.com)

Table 10. Complementary partners

Compliance and approval

Compliance and approbation

The Fortimo SLM Module together with Xitanium LED Drivers comply with the appropriate U.S. safety standards.

The relevant standards are on page 31. To ensure luminaire approval, the conditions of acceptance need to be fulfilled. Details can be requested from your local Philips sales representative. All luminaire manufacturers are advised to conform to the UL standard for safety UL1598 or Canadian standard CSA 250-13.

IP rating, humidity and condensation

The Fortimo LED SLM Modules are build-in modules relying on the luminaire for environmental protection. They have no IP classification.

The Fortimo LED SLM has been developed and released for use in dry or damp locations. If there is a possibility that condensation could come into contact with the modules, the luminaire builder must take precautions to prevent this.

Electrostatic discharge (ESD)

ESD in production environment

Depending on the protection level of the LED module, a minimum set of measures has to be taken when handling LED boards. Philips LED products have a high degree of ESD protection by design. ESD measures are required in a production environment where values can exceed the values shown in the ESD specifications table (Table 11) below.

ESD specifications

Specifications for Fortimo LED SLM Gen 4:

Discharge	Model
<8 kV	Human Body Model (HBM) ANSI/ESD STM5.1-2007
<400V	Machine Model (MM) Class B JESD22-A115-B

Table 11. ESD specifications

Chemical compatibility

The CoB contains a silicone overcoat to protect the LED chip and extract the maximum amount of light. As with most silicones used in LED optics, care must be taken to prevent any incompatible chemicals from directly or indirectly reacting with the silicone.

The silicone overcoat used in the CoB is gas sensitive. Consequently, oxygen and volatile organic compound (VOC) gas molecules can diffuse into it. VOCs may originate from adhesives, solder fluxes, conformal coating materials, potting materials and even some of the inks that are used to print the PCBs.

A list of commonly used chemicals that should be avoided, as they may react with the silicone material, is provided in Table 12. Note that Philips does not warrant that this list is exhaustive because it is impossible to determine all chemicals that may affect LED performance. These chemicals may not be directly used in the final products, but some of them may be used in intermediate manufacturing steps (e.g., cleaning agents). Consequently, trace amounts of these chemicals may remain on (sub) components, such as heat sinks. It is recommended to take precautions when designing your application.

Chemical Name	Type
Hydrochloric acid	acid
Sulfuric acid	acid
Nitric acid	acid
Acetic acid	acid
Sodium Hydroxide	alkali
Potassium Hydroxide	alkali
Ammonia	alkali
MEK (Methyl Ethyl Ketone)	solvent
MIBK (Methyl Isobutyl Ketone)	solvent
Toluene	solvent
Xylene	solvent
Benzene	solvent
Gasoline	solvent
Mineral spirits	solvent
Dichloromethane	solvent
Tetracholorometane	solvent
Castor oil	oil
Lard	oil
Linseed oil	oil
Petroleum	oil
Silicone oil	oil
Halogenated hydrocarbons (containing F, Cl, Br elements)	misc
Rosin flux	solder flux
Acrylic Tape	adhesive

Table 12. Common chemicals to avoid

Philips Fortimo LED SLM Gen 4 Modules comply with the U.S./Canadian standards and regulations shown below.

Safety

UL 8750	LED modules for general lighting – safety specifications
CSA 250.13	CSA standard for LED modules

Philips Advance Xitanium Driver

UL 8750/UL1310	Lamp control gear

Electromagnetic compatibility

(Tested with Fortimo LED SLM Gen 4 Modules and Philips Advance Xitanium Driver)

FCC part 15	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
	Equipment for general lighting purposes – EMC immunity requirements

Cautions

During storage and transportation

- Store in a dark place. Do not expose to sunlight.
- Maintain temperature between -40 ~ +80°C, and RH 5 – 85%.

During operation

Philips shall not be held responsible for any damage to the user resulting from an accident or any other cause during operation if the system is used without due observance of the absolute maximum ratings.

Please note that warranty is applicable for the Philips Fortimo LED SLM Modules for one switching cycle per day in combination with a UL CLASS 2 driver.

Contact details

Philips Fortimo LED SLM systems

Visit www.philips.com/ledmodulesna or contact your local Philips sales representative.

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